

Physiological Impacts of Climate Change Using Remote Sensing

David S Wethey, Sarah A Woodin, Thomas J Hilbish, Venkat Lakshmi
University of South Carolina

Brian Helmuth, Northeastern University

wethey@biol.sc.edu

Forecasting Effects of Extreme Events on Shellfisheries as a Management Tool

- Mass mortality due to heat waves in summer
- Mass mortality due to low salinity in winter
- Losses can be as high as 100%
- Hindcasting – assign blame for crop losses due to low salinity events
- Forecasting – provide time for harvesters and depuration operations to move shellfish to rafts at mouth of estuaries

www.farodevigo.es
FARO DE VIGO

Un estudio pionero en España para alertar sobre eventos climáticos extremos

Biólogos de Vigo desarrollan un sistema de predicción de olas de calor e inundaciones en bancos marisqueros

Elsa Vázquez lidera un proyecto del plan nacional que permitirá pronosticar con varios días de antelación los cambios en la temperatura o la salinidad y evitar mortandades -Colaboran las cofradías de Redondela, Carril, Campelo y Cambados

Sandra Penelas | 04.10.2015 | 09:06

Vigo lidera un proyecto pionero en España para determinar los riesgos y efectos que el cambio climático ya está ocasionando en los bancos marisqueros gallegos y cuyo objetivo último es desarrollar un sistema de predicción que alerte a las cofradías ante la llegada de olas de calor e inundaciones para que puedan tomar medidas y evitar mortandades. El estudio cuenta con financiación nacional -177.870 euros hasta 2017- y está coordinado por la catedrática de Zoología **Elsa Vázquez**. También colaboran dos expertos de la universidad estadounidense de South Carolina y cinco cofradías de la provincia -Redondela, Carril, Campelo y Cambados-, además de contar con el respaldo de la Consellería do Mar.



Las cajas de los experimentos. // J. Santomé

Fotos de la noticia

Partnership with U Vigo and 4 Fisheries Coops

Vigo biologists develop prediction system for heat waves and floods in shellfish beds

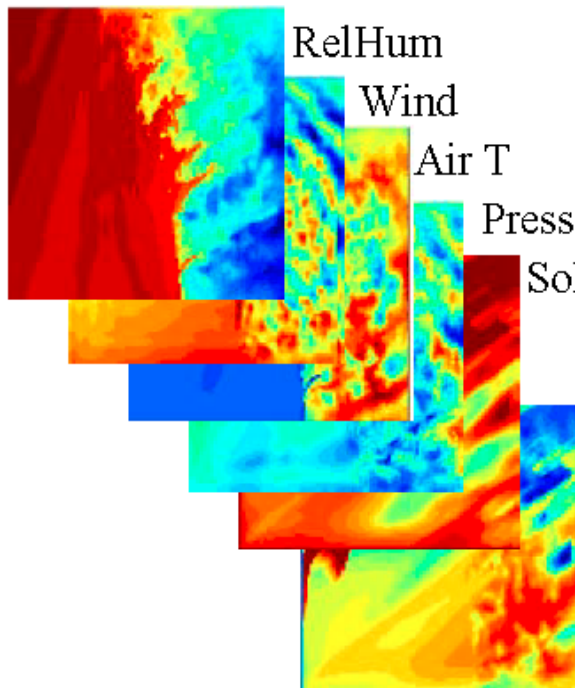
Elsa Vázquez leads a nationally funded project for predicting changes in temperature and salinity several days in advance in order to mitigate mortality risks.



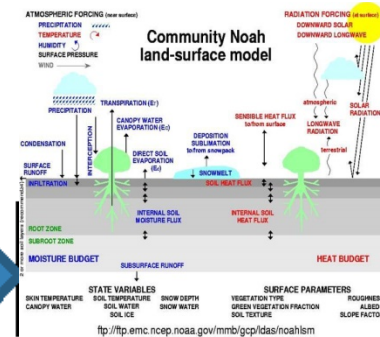
MARISCO Temperature, Salinity, and Mortality Forecasting

Meteo Galicia

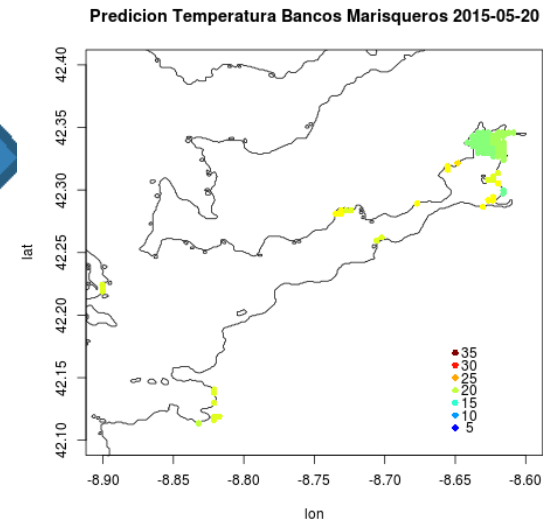
WRF Meteo Forecast



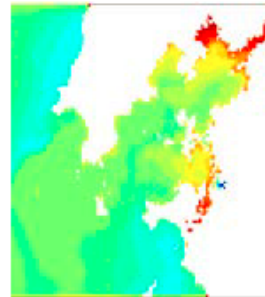
NOAH Sandflat Model



Shellfish Temperature Forecast



MeteoGalicia
MOHID Forecast SST



Forecasts at 250 m
spatial scale
within shellfish beds

Three primary clam species harvested in NW Spain



www.mariscosdelortegal.com

Venerupis corrugata

Ameixa babosa

Burrow depth ~8 cm

Avg 13€/kg Max 52€/kg in shell at dock

Total dock sales 2015 **13.7 million euros**



Ruditapes decussatus

Ameixa fina

Burrowing depth 15-20 cm

Avg 24€/kg Max 80€/kg in shell at dock

Total dock sales 2015 **13.3 million euros**



Ruditapes philippinarum (Manila Clam)

Ameixa xaponesa

Burrowing depth ~4 cm

Avg 7.5€/kg Max 27€/kg in shell at dock

Total dock sales 2015 **13.7 million euros**

Total USA Landings 2015 \$21.4 million

Total USA Mercenaria Landings 2015 \$51.6 million

Effects of Extreme Events – Mortality due to Low Salinity

Date	<i>Cerastoderma edule</i>	<i>Venerupis senegalensis (corrugata)</i>	<i>Tapes decussatus</i>	<i>Tapes philippinarum</i>	Type	Identifier
28/02/77	T (Total)	T	T	T	SM	Sev0277
22/12/78	T	T	T	T	SM	Sev1278
31/12/81	PT (Practically Total)	PT	PT	PT	SM	Sev1281
23/10/87	T	T	T	T	SM	Sev1087
28/12/89	90%	99%	10%	0%	SM	Sev1289
14/01/91	0%	80%	0%	0%	MM	Mod0191
04/01/94	0%	0%	0%	0%	MB	Morb0194
12/01/94	17%	87%	0%	0%	MM	Mod0194
19/01/96	60%	96%	5%	43%	SM	Sev0196
27/04/00	0%	80%	0%	0%	MM	Mod0400
07/12/00	0%	95	0%	0%	MM	Mod1200
27/11/02	0%	0%	0%	0%	NM	NoMort1102
16/01/03	PT	PT	PT	PT	SM	Sev0103
29/03/06	71%	50%	45%	78%	SM	Sev0306
25/11/06	0%	10%	2%	5%	MB	Mod1106
07/03/07	33%	97%	2%	6%	MM	Mod0307
05/02/09	30%	30%	7%	14%	MM	Mod0209

Laboratory Stress Experiments

Heat Waves



96 × 150W heaters
deployed
at low tide

4 temperatures/salinities (low tide – hi tide)

22-18°C	5-20 ppt
27-18	10-25
32-18	15-30
37-18	30-30

4 species

<i>V corrugata</i>)
<i>R decussatus</i>)clams
<i>R philippinarum</i>)
<i>C edule</i>	cockle

Multiple Metrics

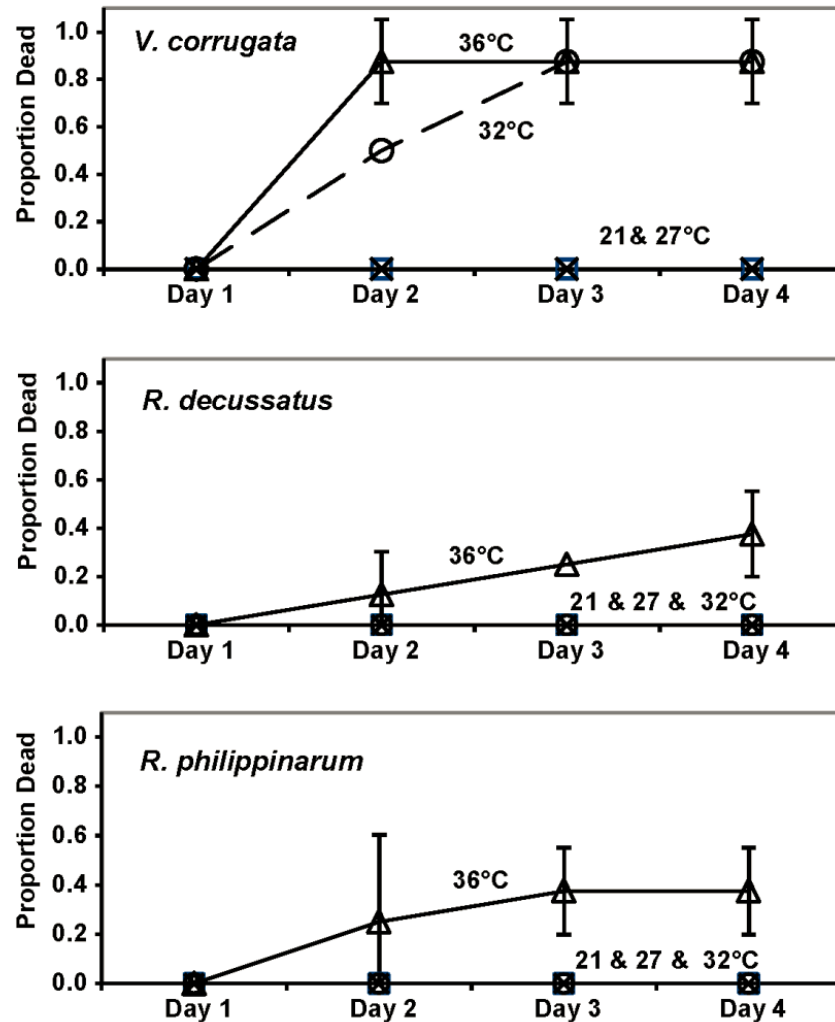
Respiration rate)scope
Feeding rate)for
Defecation rate)growth
N excretion rate	
Gonad index	
Burrowing rate	
Subsurface activity	
Mortality rate	

Mixing pumps to
deliver low salinity
water at low tide

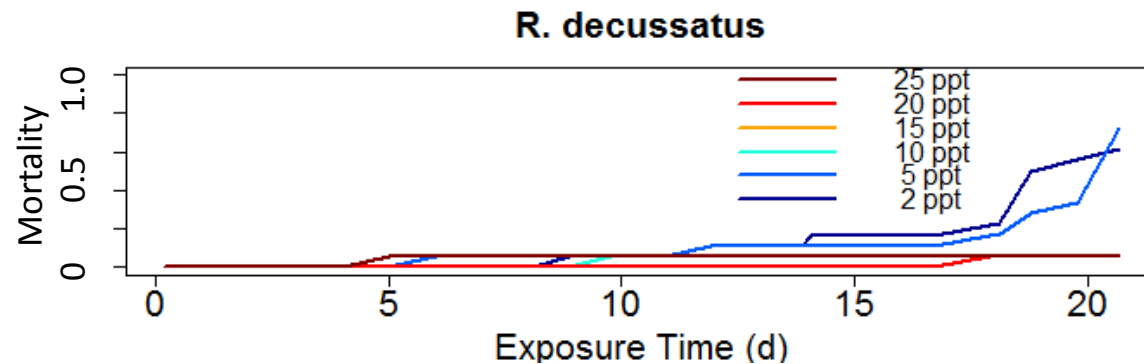
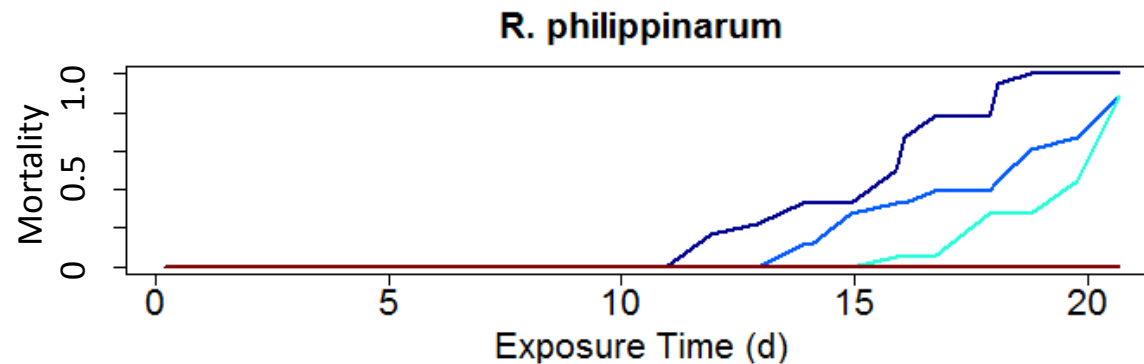
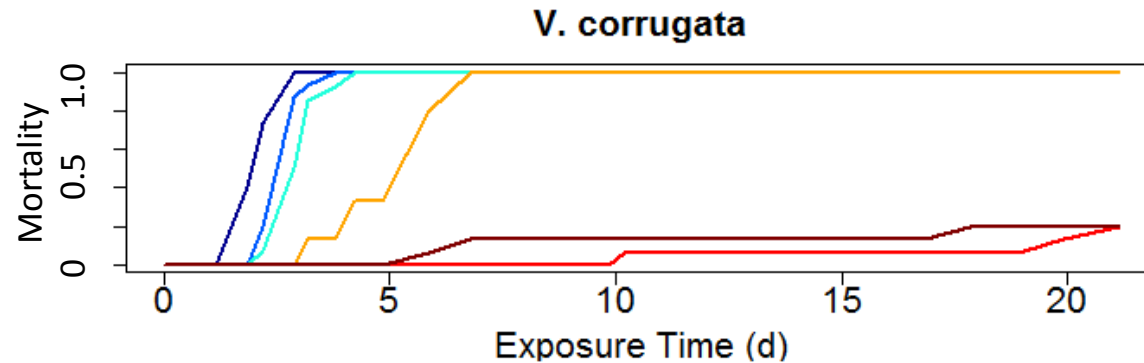
Low Salinity



Mortality from High Temperature Exposure



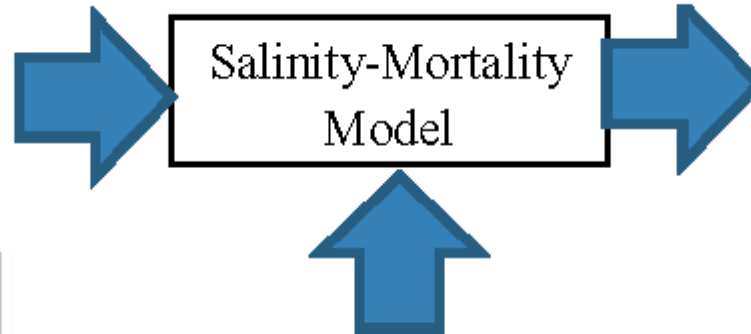
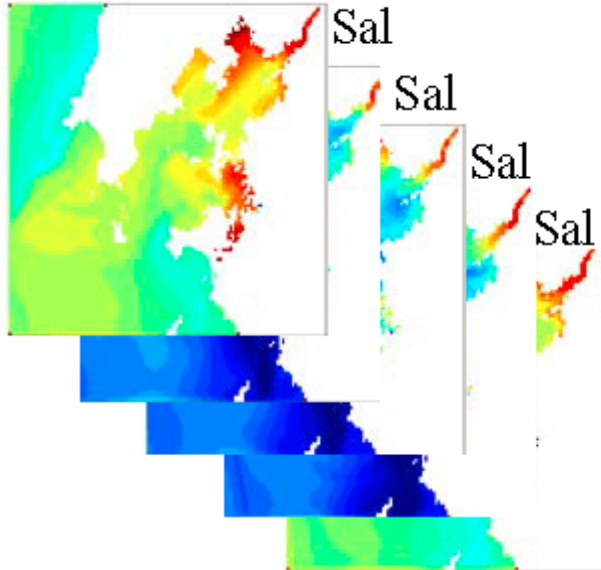
Mortality from Low Salinity Exposure



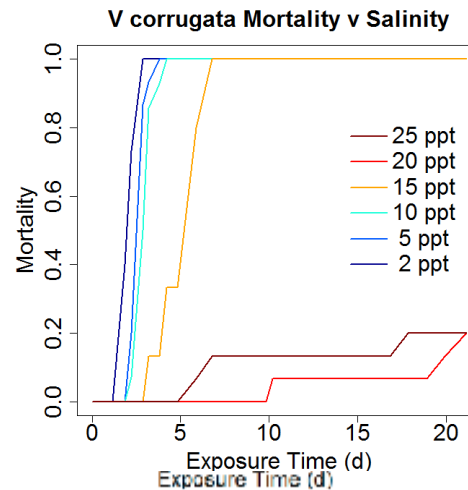
Forecasting Low Salinity Exposure Effects in Sandflats: Mortality

MeteoGalia

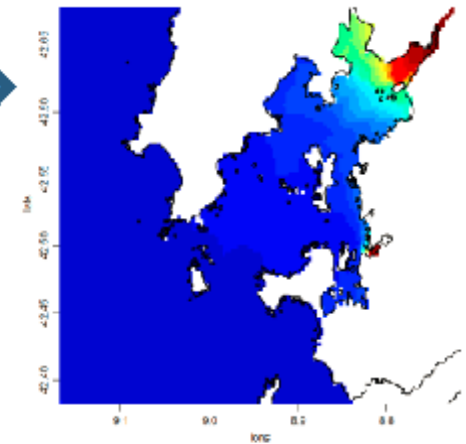
MOHID Ocean Forecast



Laboratory Experiments

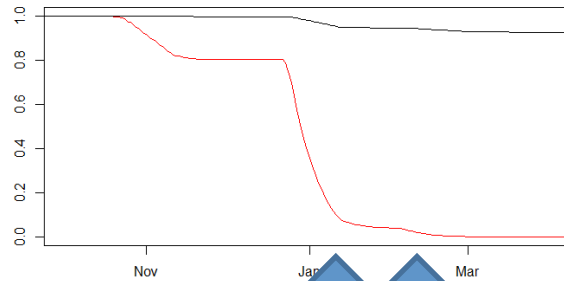
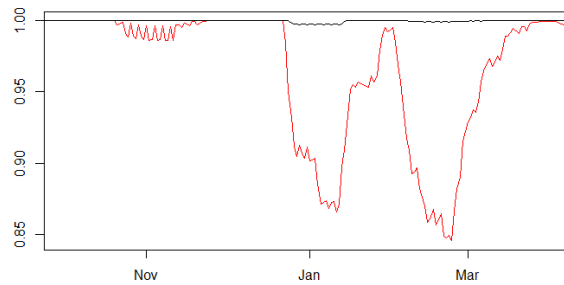


Shellfish Mortality Forecast



Forecasts at 250 m spatial scale within shellfish beds

V corrugata Mortality



Diario de Arousa.com



Los arenales se llenan de almejas muertas que confirman pérdidas millonarias en Carril

S. L. vilagarcia | 08 de Febrero de 2014



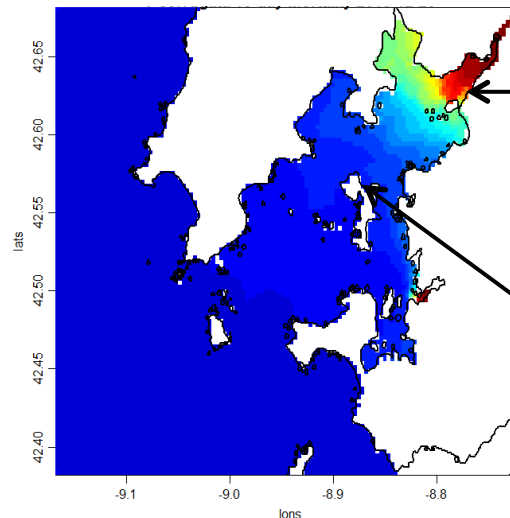
Conchas y almejas muertas por la baja salinidad del agua llenan ya las playas G. Salgado

Catastrophic harvest losses in winter 2013-2014:
heavy rains caused low salinity in upper Ría de Arousa

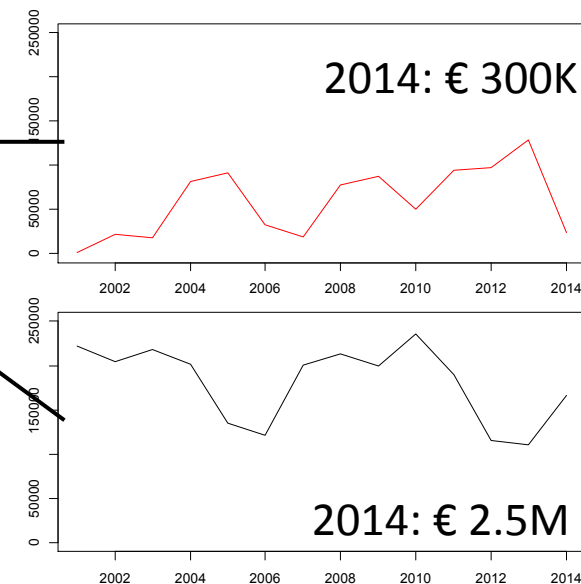
Our model predicted high mortality in the upper estuary at time of reports of mass mortality (RED)

Also predicted low mortality in the mid estuary where low mortality was observed (BLACK)

V corrugata Mortality

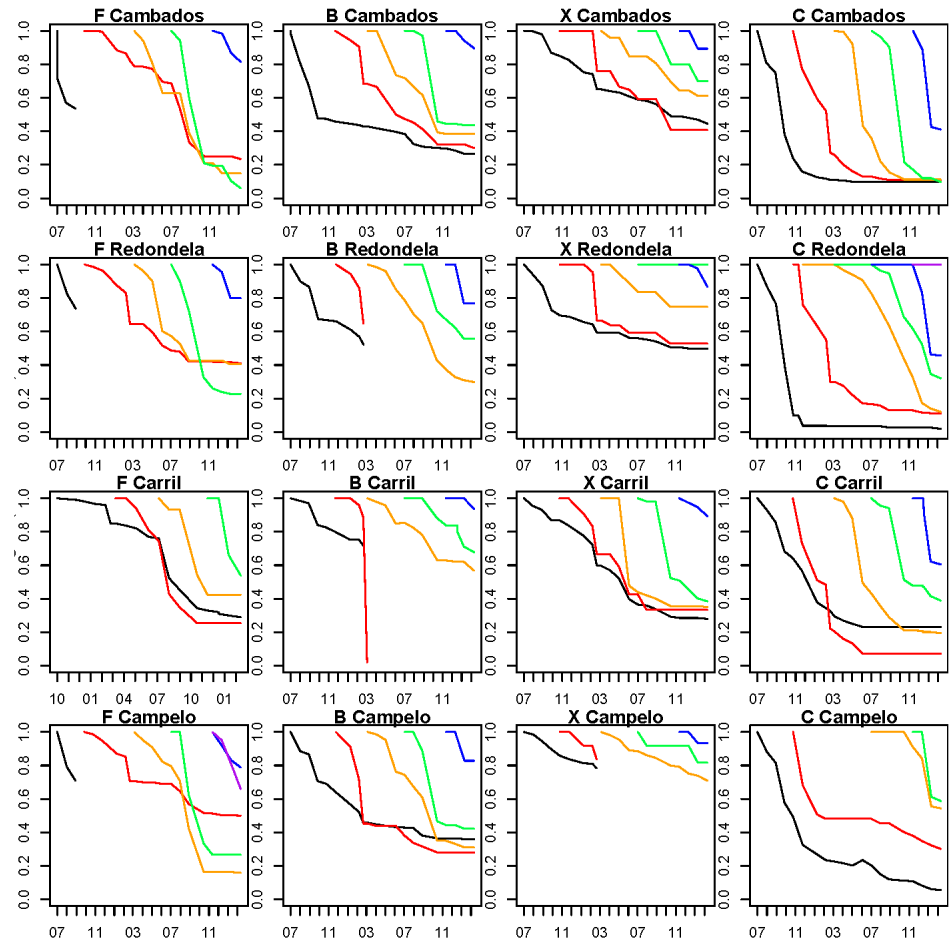
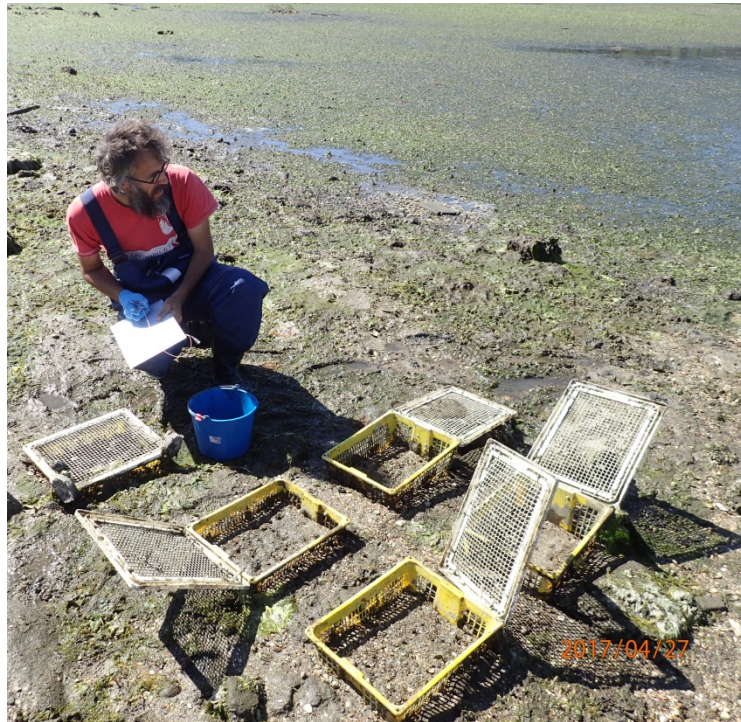


V corrugata Harvest



Long Term Field Survival

Field Cages – 4 species at 4 sites

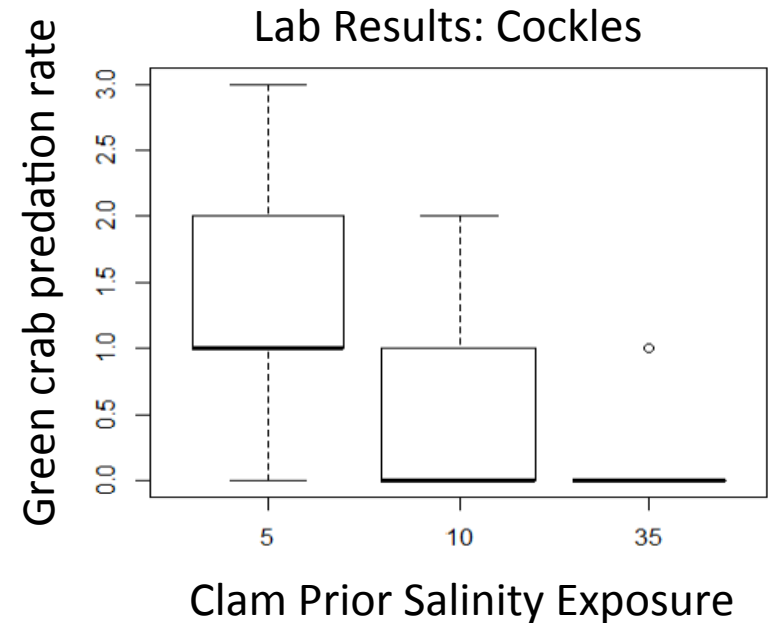


Winter rains affected most sensitive species

Indirect Effects of Low Salinity on Clams

Increased Predation Risk

Field Salinity/Predation Manipulation



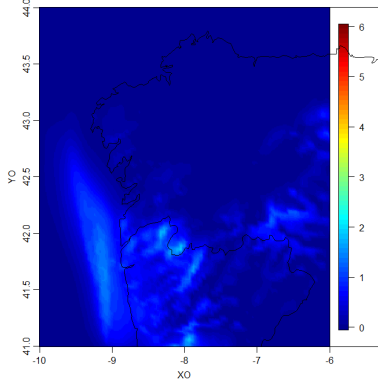
Green crabs have invaded US, so these risks may emerge here

Socioeconomics

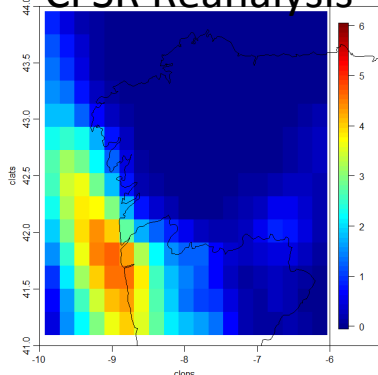
- Focus groups and questionnaires
 - 19 respondents from one cooperative
 - 95 from another
- Primary concerns over past 10 years
 - Reduced harvests of all clam species
 - Less household income
 - 50% of respondents needed some public assistance
 - Shellfishing provides average of 90% of personal income and 65% of family income
 - Shellfishing income often below poverty level (typical income €7000 per person per year).

Rainfall/Salinity Hindcasts for Recovery of Financial Losses

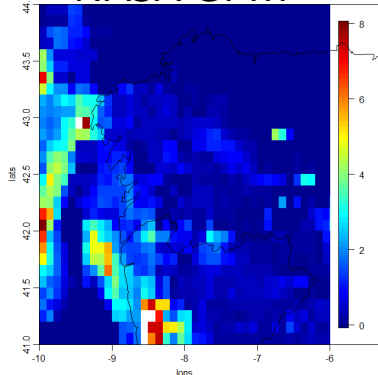
WRF model forecast



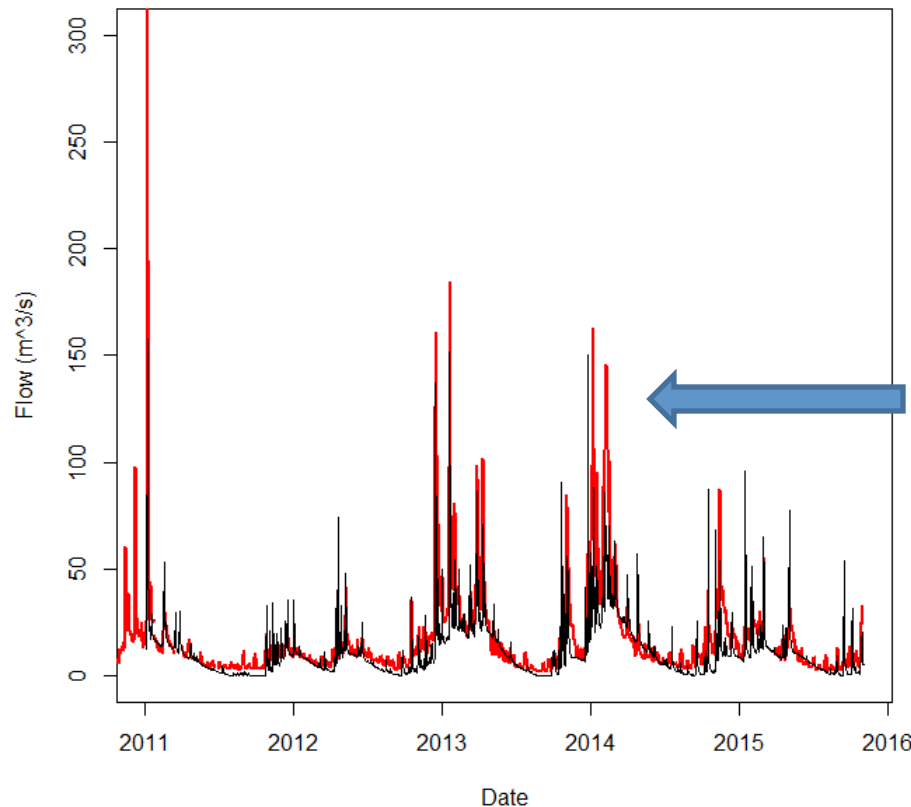
CFSR Reanalysis



NASA GPM



Umia SWAT Model (B) vs Flow Gauge (R)



Dam operations not included in SWAT model

Hydroelectric dams used for peaking power generation in winter when consumers use electric heat.

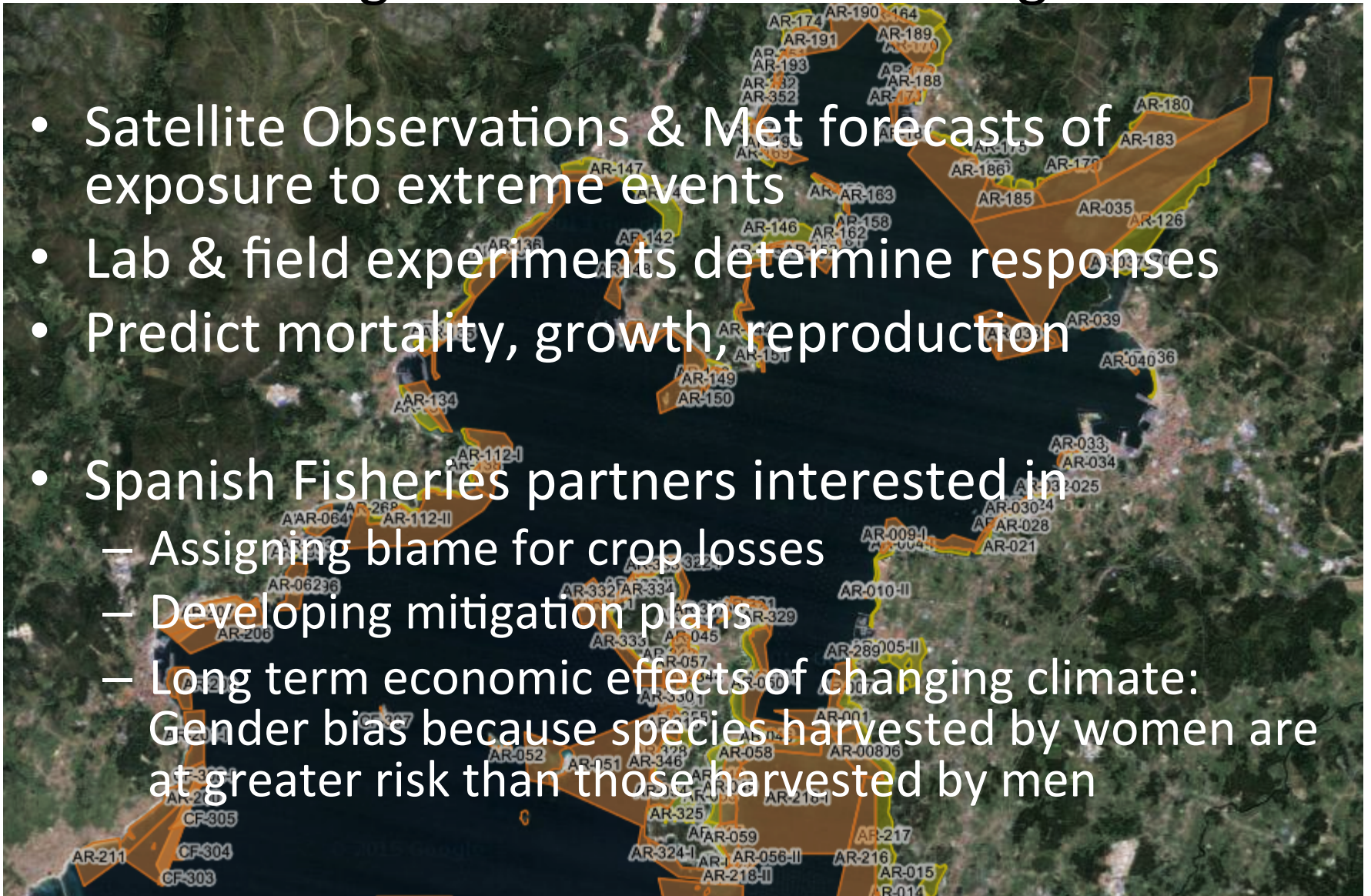
During peaking power generation, river flow is higher than expected from SWAT rainfall-runoff relationship.

SWAT and Flow data: MeteoGalicia

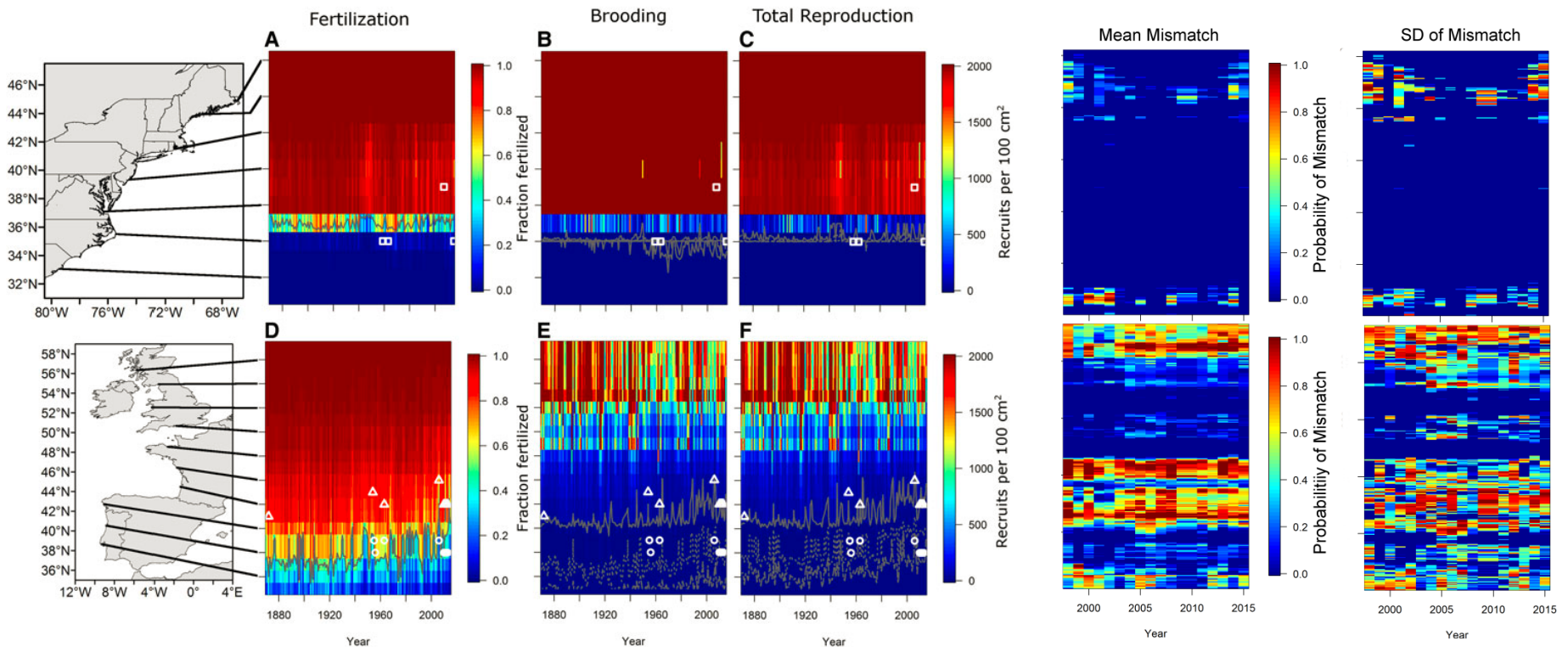
Coops can sue the power companies if they are to blame for low salinity and associated crop losses

Modeling for Shellfisheries Management

- Satellite Observations & Met forecasts of exposure to extreme events
- Lab & field experiments determine responses
- Predict mortality, growth, reproduction
- Spanish Fisheries partners interested in
 - Assigning blame for crop losses
 - Developing mitigation plans
 - Long term economic effects of changing climate: Gender bias because species harvested by women are at greater risk than those harvested by men



Multiple Mechanisms set Geographic Limits in Different Regions – North Atlantic Barnacles



US Coast - Fertilization and Brooding Failure

European Coast – Fertilization and Plankton Mismatch for Larvae, Depending on Region